E2BMO
Engineering to Biomimetic Ontology

Facilitating user interaction with a biomimetic ontology through semantic translation and interface design

Introduction

Tools for Biomimicry

A recent review by Wanieck et al. (2017) identified numerous tools that help facilitate the biomimicry process, ranging from biological archives and literature navigation tools, to design theory publications and interdisciplinary semantic translation tools. Upon exploration of these tools as an interdisciplinary team, we found that although there are copious tools available to facilitate the biomimicry process, the transition from one tool to another is a difficult and rarely addressed challenge. Therefore, two tools were identified that, if bridged, could facilitate a more systematic approach to biomimicry, thus addressing this identified challenge: the Biomimetic Ontology (J.F.V. Vincent) and the Engineering to Biology Thesaurus (J. Nagel).

Dr. Julian Vincent's Biomimetic Ontology

Julian Vincent is currently developing an ontology that aims to bridge the gap between engineering and biology. By using TRIZ trade-offs, he specifically facilitates access to biological strategies for engineering practitioners. In TRIZ, trade-offs serve to break down problems and find innovative solutions, called Inventive Principles. Due to ontologies potential to organize complex collections of data and to be merged together, they are used across a variety of fields. Finding biological strategies from an engineering point of view is one of the most difficult steps in the biomimicry process to be identified by users. Julian Vincent has translated a large amount of biological knowledge from scientific papers to TRIZ trade-offs and Inventive Principles. An ontology is still viewed as a complex data collection. Facilitating access to this source of knowledge could help many other professionals, especially from the engineering discipline, in their biomimicry research.

Engineering to Biology Thesaurus

The Engineering-to-Biology Thesaurus (E2B Thesaurus) is a hierarchical collection of engineering and biology terms that allows practitioners to easily transfer functions from one discipline's terminology to the other. It was developed to encourage collaboration by creating links between biology and engineering, and increase accessibility of biological knowledge for engineers. Once relevant biological terminology is acquired, scientific literature and other biomimetic tools can be explored to identify potential biological models for application.

It is clear that both of these tools assist specific steps of the biomimicry process but the transition to and from these steps is not trivial. It is common amongst biomimicry tools that the information output from one does not adequately serve as useful input for another creating hurdles between steps of the overall design process. Therefore, finding a way to make these tools communicate could ease and enhance the overall biomimicry process.

Methods and Results

Based on our review of existing tools for biomimicry, the main limitations addressed for this project are the lack of connection between tools, difficulty of knowledge transfer between steps, and the complexity for non-expert users to get useful information out of the tools.

Building a semantic interface with the Simplified Knowledge Organization System (SKOS)

To combine the E2B Thesaurus and the Biomimetic Ontology (BMO), we needed to generate an electronic version of the E2B Thesaurus that could interact and/or communicate with the BMO. We accomplished this by expressing the E2B Thesaurus as a Simplified Knowledge Organization System (SKOS), a method and vocabulary for organizing semantic information. All terms included in SKOSs are categorized into one of two categories: concepts or concept schemes. Concepts are the main elements of a SKOS; they are the specific terms from the original knowledge organization system (in this case, terms from the E2B Thesaurus). Associated concepts can then be organized into concept schemes. Once concepts and concept schemes are generated, various semantic relationships can be implemented between concepts to create a cohesive classification system. We chose SKOS because it allows terms to be loosely connected in an organized and hierarchical framework that could be linked with an ontology directly.

To create this link between SKOS and the Biomimetic Ontology, Biological Function Correspondents were manually connected to Inventive Principles within Protégé, an ontology editor software.

User-friendly interface and querying design

Protégé was also used to export the combined reasoned ontology into an Resource Description Framework (RDF) format. In order to query this RDF file, a website based on SPARQL, a semantic query language, was developed to retrieve the ontology knowledge. Three methods of querying this E2B combined Bio-Ontology are available: 1) Using trade-off concepts in the BMO: showing biological organisms that have developed mechanisms dealing with such trade-offs, and their solutions in form of Inventive Principles; 2) Using E2B terms, displaying a hierarchical graph where users can explore various terms to narrow down their search. Each possibility is also matched to potential solutions using the Inventive Principles. 3) Using a graph where users can explore the whole ontology while filtering desired information

Conclusion

The synergy between the E2B thesaurus, the Biomimetic Ontology, and a user-friendly interface not only increases the effectiveness of interdisciplinary translation, but also grants users easier access to and navigation in the ontology. Our efforts to link the thesaurus and ontology will help people to more easily understand and use ontologies for complex systems, bridge gaps between steps in the biomimicry process, and open greater potential for future biomimicry practice.

References

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